IDA DOCUMENT D-571

AN ANNOTATED READING LIST FOR CONCURRENT ENGINEERING

James P. Pennell
Marko G. Slusarczuk

July 1989

Prepared for
Office of the Assistant Secretary of Defense for
Production and Logistics (OASD(P&L))

INSTITUTE FOR DEFENSE ANALYSES
1801 N. Beauregard Street, Alexandria, Virginia 22311-1772

IDA Log No. HQ 89-034130

DEFINITIONS

IDA publishes the following documents to report the results of its work.

Reports

Reports are the most authoritative and most carefully considered products IDA publishes. They normally embody results of major projects which (a) have a direct bearing on decisions affecting major programs, or (b) address issues of significant concern to the Executive Branch the Congress and/or the public, or (c) address issues that have significant economic implications. IDA Reports are reviewed by outside panels of experts to ensure their high quality and relevance to the problems studied, and they are released by the President of IDA.

Group Reports

Group Reports record the findings and results of IDA established working groups and panels composed of senior individuals addressing major issues which otherwise would be the subject of an IDA Report. IDA Group Reports are reviewed by the senior individuals responsible for the project and others as selected by IDA to ensure their high quality and relevance to the problems studied, and are released by the President of IDA.

Papers

Papers, also authoritative and carefully considered products of IDA, address studies that are narrower in scope than those covered in Reports. IDA Papers are reviewed to ensure that they meet the high standards expected of refereed papers in professional journals or formal Agency reports.

Documents

IDA Documents are used for the convenience of the sponsors or the analysts (a) to record substantive work done in quick reaction studies, (b) to record the proceedings of conferences and meetings, (c) to make available preliminary and tentative results of analyses, (d) to record data developed in the course of an investigation, or (e) to forward information that is essentially unanalyzed and unevaluated. The review of IDA Documents is suited to their content and intended use.

The work reported in this document was conducted under contract MDA 903 89 C 0003 for the Department of Defense. The publication of this IDA document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that agency.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 1989	Final

4. TITLE AND SUBTITLE
An Annotated Reading List for Concurrent Engineering

5. FUNDING NUMBERS
MDA 903 89 C 0003
T-B5-602

6. AUTHOR(S)
James P. Pennell, Marko M.G. Slusarczuk

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Institute for Defense Analyses
1801 N. Beauregard St.
Alexandria, VA 22311-1772

8. PERFORMING ORGANIZATION REPORT NUMBER
IDA Document D-571

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of the Assistant Secretary of Defense for Production and Logistics (OASD(P&L))
Room 2B322, The Pentagon
Washington, D.C. 20301

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, unlimited distribution.

12b. DISTRIBUTION CODE
2A

13. ABSTRACT ***(Maximum 200 words)***

The purpose of IDA Document D-571 is to provide an annotated bibliography on concurrent engineering. This document is intended to help the reader who is unfamiliar with concurrent engineering understand the several fields of study involved and also to allow those who are experts in some narrower subject gain an appreciation for work in related topics.

14. SUBJECT TERMS
Concurrent Engineering; Statistical Process Control; Design of Experiments; Design for Assembly; Productivity and Quality; Manufacturing; Education and Training.

15. NUMBER OF PAGES
60

16. PRICE CODE

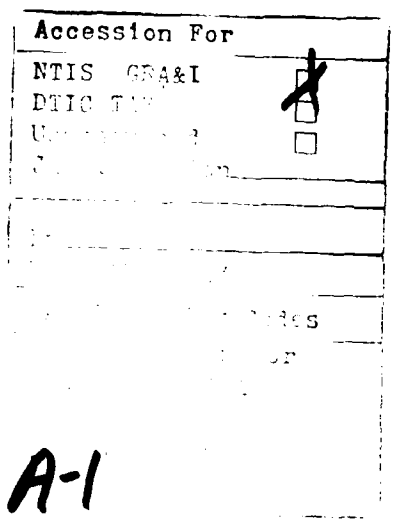
17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

IDA DOCUMENT D-571

AN ANNOTATED READING LIST FOR CONCURRENT ENGINEERING

James P. Pennell
Marko G. Slusarczuk

July 1989



IDA

INSTITUTE FOR DEFENSE ANALYSES

Contract MDA 903 89 C 0003
Task T-B5-602

IDA Document D-571
An Annotated Reading List for Concurrent Engineering

James P. Pennell
Marko M. G. Slusarczuk

Institute for Defense Analyses
1801 North Beauregard St.
Alexandria, VA 22311
(703) 845-2000

1. Background

This document is provided in response to a request by the sponsor for information to supplement IDA Report R-338, *The Role of Concurrent Engineering in Weapons System Acquisition*. That report describes the findings of Phase I of a joint IDA, DOD, industry, and academia investigation of concurrent engineering.

2. Objective

This annotated bibliography is intended both to help the reader who is unfamiliar with concurrent engineering understand the several fields of study involved and also to allow those who are experts in some narrower subject gain an appreciation for work in related topics. It cites a variety of sources and gives a short note about each.

3. Using the List

The authors have attempted to avoid editorial judgements in the bibliography. The reader should be aware that individual works are sometimes in conflict and that inclusion of a particular piece in this list does not constitute an endorsement by the authors.

3.1. Getting Started

The following works are recommended for the reader interested in getting an overview of the problems facing U.S. companies and some of the most promising solutions:

- Ackerman *et al.* (1987) provide an excellent guide to understanding and managing "the process."
- Deming (1986) gives an excellent exposition of need to understand variability and his famous 14 point management philosophy.
- Garvin (1987) defines eight dimensions of quality.
- Hayes (1988) offers a manager's perspective of the problem and some solutions.
- Ishikawa (1982) presents a practical guide (with easy to use tools) for implementing quality control at the working level.
- Schonberger (1987) describes Japanese and American modern manufacturing techniques.

3.2. Statistical Process Control

Readers who are interested in statistical process control can consult the 1985 ANSI Standard or Wheeler (1986) for a description of the basics of control charts. More advanced tools are described in Page (1954), Hunter (1986), and Woodward (1964).

3.3. Design of Experiments

Design of experiments is described by Box *et al.* (1978) Copp (1984), Kackar (1985), Schmidt (1988), Shoemaker (1988), Snee (1979), and Taguchi (1988). The reader will quickly become aware of a controversy concerning tactics of experimental design among those who follow the recommendations of Taguchi and those who prefer other approaches. If the reader wishes to pursue this subject, then Kackar's 1986 article and Schmidt's text are good starting points. Other commentaries such as Box (1988), Leon *et al.* (1987), Kusaba (1988), and Winner (1988) can be found in the bibliography.

3.4. Design for Assembly

Design for assembly is described by Boothroyd and Dewhurst, Gager (1986), and Schreiber (1985).

3.5. Productivity and Quality

Readers seeking information about problems with productivity and quality from the government's view can consult two blue-ribbon reports Costello (1988) and Packard (1986). They can also find recommended approaches for acquisition programs in Willoughby (1986), the Air Force's R&M 2000, and DoD 4245.7. Government programs to motivate and reward improvements in productivity among federal employees are described by Feher *et al.* (1985) and Riedel *et al.* (1987).

3.6. Manufacturing

Black (1988), Freeman (1985), Gansler (1988), Haas (1987), Hayes (1988), Jurgen (1986), Knight (1989), Monden (1983), Schonberger (1987), and Seifert (1988) discuss various aspects of manufacturing. Jurgen's collection of essays is a good starting point for the reader who is interested in becoming familiar with the role of computers in improving manufacturing.

3.7. Education and Training

The role and importance of education are discussed in several papers. Easton, Roberts, and Tiao (1988) discuss the need for improvements in the business schools, Gomory and Shapiro (1988) have a dialogue on the relationship between the university and industry, and Hutchinson and Muller (1988) critique a proposal for revising the engineering curriculum. Landwehr and Watkins (1987) provide a text that can supplement education in the primary and secondary schools, and both Marquardt (1984) and Tribus (1988) address the educational needs of senior management. Rohlen (1987) shows why the Japanese educational system works.

3.8. Research Directions

Research directions and reports of current research can be found in NCMS (1988), DARPA (1987), Dornfield (1989), and Fox (1989).

4. Caution

The attached bibliography is not exhaustive, it represents principal works that the authors' found useful during the first phase of investigating concurrent engineering. Readers can develop their own reading list after consulting the works cited here or they may choose to contact any of the professional societies that have continuing activities in a particular subject area such as the Institute of Electrical and Electronic Engineers, the Institute of Industrial Engineers, the American Society for Quality Control, the American Statistical Association, the American Society of Mechanical Engineers, the American Chemical Society, American Production and Inventory Control Society, and the Japanese Union of Scientists and Engineers.

BIBLIOGRAPHY

Ackerman, Roger B. and et al., *Process Quality, Management & Improvement Guidelines,* AT&T Bell Laboratories, 1987.

This book gives rules for process management and improvement. An appendix provides rule-of-thumb for techniques to apply at each step of seven-step procedure. Describes several software tools.

American Supplier Institute, *Third Supplier Symposium on Taguchi Methods,* American supplier Institute, Detroit, MI, October 8-9, 1985.

This document provides the proceedings of the third symposium on Taguchi Methods. Sponsorship changed from Ford Motor Company to American Supplier Institute.

American Supplier Institute, *Fourth Symposium on Taguchi Methods,* American Supplier Institute, Detroit, MI, October 1986.

This symposium is a continuation of the effort begun by Ford Motor Company in 1984.

American Supplier Institute, *Fifth Symposium on Taguchi Methods,* American Supplier Institute, Detroit, MI, October 1987.

This symposium is a continuation of the effort begun by Ford Motor Company in 1984.

ANSI, and ASQC, *American National Standard: Guide for Quality Control Charts, Control Chart Method of Analyzing Data, Control Chart Method of Controlling Quality During Production: ASQC Standard B1-1985, B2-1985 & B3-1985 ANSI Z1-1985, Z1.2-1985 & Z1.3-1985,* American Society for Quality Control, Milwaukee, WI, 1985.

These standards evolved from the original work of Dodge, Ashcroft. Deming, Simon, Wareham, and Gaillard for the War Department in 1940. They are contained in a single document. The document shows the user how to use statistical process control.

ASD(A&L), *Transition from Development to Production DoD 4245.7-M,* Department of Defense, Washington, DC, September 1985.

This manual contains "The Templates." They provide an example of how one goes about ensuring that the transition from development to production is as smooth as possible by providing the discipline to help users make wiser decisions. A "Template" describes specific areas of risk and outlines steps for reducing risk. There are separate templates for over 40 tasks.

Bisgaard, Sören, *A Practical Aid for Experimenters,* University of Wisconsin–Madison, Madison, WI, 1988.

The author provides a workbook of experimental design worksheets. The worksheets provide experimental layouts for eight and sixteen run experiments, with Yates algorithm for each, plots for square, cube, and double-cube, and normal probability paper for eight and sixteen run experiments.

Black, J. T., "The Design of Manufacturing Cells (Step One to Integrated Manufacturing Systems)," *Proceedings of Manufacturing International '88,* vol. III, p. 143, April 19, 1988.

The author discusses the five basic kinds of manufacturing systems, including the newest–cellular manufacturing systems (CMS).

Black, J. T. and B. J. Schroer, "Decouplers in Integrated Cellular Manufacturing Systems," *Journal of Engineering for Industry*, vol. 110, pp. 77-85, ASME, February 1988.

The authors describe a new element, a decoupler, that must be added to the cellular manufacturing system to allow it to satisfy the primary functional requirement of flexibility.

Boothroyd, G. and P. Dewhurst, *Early Cost Estimating in Product Design*, Department of Industrial and Manufacturing Engineering University of Rhode Island, Kingston, RI, March 1987.

This report is one in a series of over 20 research papers describing topics such as robot assembly, expert systems in design for assembly (DFA) printed circuit board DFA, injection molding, laminated fibrous/epoxy, composite structures, and CAD for multi-stage cold forging.

Boothroyd Dewhurst Inc., *Design for Assembly Handbook*, Wakefield, 1985.

This is a design for assembly handbook.

Box, George E. P., "Evolutionary Operation: A Method for Increasing Industrial Productivity," *Applied Statistics*, June 1957.

The author describes a method that can be used on the shop floor to allow production systems to evolve, through observation and experimentation so that productivity is continually improved.

Box, George E. P., William G. Hunter, and J. Stuart Hunter, *Statistics for Experimenters*, John Wiley & Sons, New York, 1978.

This is a textbook and reference for design, data analysis, and model building using statistical design of experiments.

Box, George E. P. and Norman R. Draper, *Empirical Model-Building and Response Surfaces*, John Wiley & Sons, New York, 1987.

The authors provide an explanation of the use of response surfaces as a technique for analyzing and interpreting experimental data.

Box, George E. P., "Signal-to-Noise Ratios, Performance Criteria, and Transformations," *Technometrics*, vol. 30, No. 1, pp. 1-40, American Statistical Association and the American Society for Quality Control, February 1988.

The author provides an analysis of Taguchi's performance criteria, "signal-to-noise" ratio along with a more general approach called *lambda plots*. The author argues that improvement of quality will best be catalyzed by engineers using elementary data analysis with computer graphics rather than by those trained to employ more rigid predecided criteria. Includes five sets of commentary by Anne C. Shoemaker, Kwok-Leung Tsui, and Ramon V. Leon; William C. Parr; Raymond J. Carroll; Neil R. Ullman; and the author, Box.

Box, George E. P., Søren Bisgaard, and Conrad Fung, "An Explanation and Critique of Taguchi's Contributions to Quality Engineering," *Research Reports of the University of Wisconsin-Madison, Center for Quality and Productivity Improvement*, March 1988.

One of a series of research reports by the authors, who are members of the Center for Quality and Productivity Improvement at the University of Wisconsin–Madison. Other reports include "Doing More With Less in the Public Sector: A Progress Report from Madison, Wisconsin," "The Scientific Context of Quality Improvement," and "The Quality Detective: A Case Study."

Box, George E. P., *When Murphy Speaks–Listen,* Center for Quality and Productivity Improvement, University of Wisconsin–Madison, Report No. 34, Madison, WI, February 1989.

Referring to the Murphy of "Murphy's Laws" the author provides a discussion of the need to listen to a process. If there is an error or bug in the process, Murphy guarantees that its symptoms will become evident. The clever operator will listen to Murphy and improve the process. (Murphy's Laws are a collection of observations attesting to the fact that anything which can go wrong will eventually go wrong.)

Carrie, A. S., "Group Technology: Part Family Formation and Machine Grouping Techniques," *MAPEC Project*, Purdue University, 1978.

The author discusses the connection between part families and the arrangement of machines to fabricate the parts of a family.

Christiansen, Donald, *Engineering Excellence Cultural and Organizational Factors,* IEEE Press, New York, 1987.

This is a collection of essays organized by four parts: the importance of the individual engineer, a comparison of engineering cultures, institutional and organizational factors, and home and abroad.

Copp, Richard, *Report on Japanese Quality Engineering Using Designed Experiments–The Taguchi Method,* American Supplier Institute, Dearborn, MI, July, 1984.

The author describes the Taguchi approach and says it differs for the U.S. approach because instead of attempting to reduce variation, it seeks to reduce the effects of variation.

Costello, Robert B., *Bolstering Defense Industrial Competitiveness: Preserving our Heritage–The Industrial Base Securing Our Future Report to the Secretary of Defense by the Under Secretary of Defense (Acquisition),* Department of Defense, Washington, DC, July 1988.

The author presents the results of an examination of the problems facing the defense manufacturing base. Concludes that cooperation is an essential foundation to meeting and sustaining defense goals. Six strategic thrusts are identified: (1) forging the right relations with industry; (2) improving the acquisition system; (3) establishing defense industrial strategic plans that support military strategic plans; (4) developing manufacturing capabilities concurrent with the development of weapons systems; (5) laying the foundation now for the technical skill base required for tomorrow's defense needs; and (6) ensuring that industrial base issues important to defense benefit from a full spectrum of potential remedies.

Crosby, Philip P., *Quality is Free–The Art of Making Quality Certain,* New American Library, New York, 1979.

The author asserts that there is no reason not to do things right the first time. He shows that, contrary to previously held beliefs, better quality is not more expensive. Because of the lower costs associated with better qualilty, *viz.* less rework, scrap and repair, improved quality produces significant savings.

DARPA, *Workshop on Concurrent Design, Key West, FL,* DARPA, Washington, DC, December 1-3, 1987.

This is a collection of briefings and discussions about concurrent engineering research and applications in government and industry.

David, A. J. and et al., *Quality by Design: A Quality Manual for the AT&T R&D Community,* AT&T Bell Laboratories Quality Assurance Center, Holmdel, NJ. 1987.

This manual is designed to be used by project managers, production definition and system enginering, design, implementation, test and qualification, deployment, administra-

tive systems, and research/exploratory development. It suggests how the basic techniques of quality assurance can be applied in each of the above phases to define, monitor, control, and the appropriate process so as to improve the quality of the system.

Davis, Ruth and et al., *Industrial Insights on the DoD Concurrent Engineering Program*, The Pymatuning Group, Rosslyn, VA, October 1988.

The authors provide an analysis, from the perspective of senior managers, of the recent DoD involvement in concurrent engineering.

Defense Science Board, "Nation of Japan's Industrial and Technology Direction–Annex A," *The Defense Industrial and Technological Base*, Defense Science Board 1988 Summer Study Task Force, 20 July 1988.

This report was prepared for the DSB by experienced professionals based in Japan. Intended to be objective, it also focuses on information processing and related technology. Based on assessments of MITI 2000 it gives a view of part of the Japanese plan for the year 2000 and beyond.

Deming, W. Edwards, *Out of the Crisis*, MIT Press, Boston, MA, 1986.

This is a description of the Deming management philosophy. The author explains the 14 points.

Department of Defense, *Military Standard: Data Item Descriptions (DIDs), Preparation of DOD-STD-963A*, Department of Defense, Washington, DC, 15 August 1986.

This instruction provides procedures for preparing DIDs.

Dewhurst, P. and G. Boothroyd, "Design for Assembly in Action," *Assembly Engineering*, Hitchcock Publishing Company, January 1987.

This article describes how design for assembly was used on the IBM Proprinter. Part count reduction, assembly time reduction, cost benefits are discussed. The authors also compare automated versus manual assembly.

Dorghman, M. A., *International Journal of Computer Applications in Technology*, vol. Volume 1, Nos. 1/2, Inderscience Enterprises Ltd,, Coventry, UK, 1988.

The initial issue of this journal included articles on INCCA (The International Network of Centers for Computing Applications), developments in computer and communication technologies, electronic data interchange methodologies. linking manufacturing complexity to choices in computer-integrated-manufacturing (CIM), user interface design for CIM, management control in a distributed system, expert systems, geometric modelling systems, and numerical and experimental analysis of the residual stresses in welding processes.

Dornfield, David A., "Advances in Manufacturing Systems Integration and Processes," *Conference Proceedings, 15th Conference on Production Research and Technology*, Society of Manufacturing Engineers, Dearborn, MI, January 9-13, 1989.

This document contains over 80 papers organized as follows: machine tools and robotics; sensors and controls; cutting and grinding; assembly and fixtures; forming; casting; welding; CAD/CAM; systems management; and composites and plastics.

Easton, George, Harry V. Roberts, and George C. Tiao, "Conference Report: Making Statistics More Effective in Schools of Business," *Journal of Business & Economic Statistics*, vol. Vo. 6, No. 2, pp. 247-260, April 1988.

The author presents a detailed report of a conference to address the statistics curriculum in business schools. There were six workshops: curriculum–industry perspectives; curriculum–basic statistics courses; quality control, quality and productivity improve-

ment; statistical computing and graphics; forecasting and time-series analysis; and interaction of statisticians and researchers in finance, accounting, and marketing.

Feher, Bela and Mark F. Levine, *Organization Redesign for Productivity Improvement: Method and Case Study*, Navy Personnel Research and Development Center, San Diego, CA, October 1985.

This report presents the theory, principles, and methods of sociotechnical system analysis and design. A case study of an organization redesign project in a Navy ship repair organization is used to illustrate the concepts.

Feigenbaum, Armand V., *Total Quality Control*, McGraw-Hill Book Company, New York, 1983.

One of the first authors to use the term Total Quality Control, Feigenbaum argues for a more comprehensive approach to improving quality.

Ford Motor Company, *Supplier Symposium on Taguchi Methods*, American Supplier Institute, Detroit, MI, April 10, 1984.

This document presents the proceedings of the first symposium on Taguchi methods.

Ford Motor Company, *Second Supplier Symposium on Taguchi Methods*, American Supplier Institute, Detroit, MI, November 20, 1984.

This document presents the proceedings of the second symposium on Taguchi methods.

Fox, Mark S., *First Annual Conference: Center for Integrated Manufacturing Decision Systems*, Carnegie Mellon University, Pittsburg, PA, January 1989.

The conference proceedings provide a discussion of the elements of a manufacturing system architecture: design fusion, production planning, automated craftsman, factory scheduling, system control and diagnosis, and manufacturing logistics.

Freeman, Nancy Brooke, "Harley-Davidson's Race for Survival," *American Machinist*, pp. 71-75, January 1985.

The author describes Harley-Davidson's kanban-type approach, employee involvement program, and statistical process control that helped it to respond to foreign competition.

Gager, Russ, "Designing for Productivity Saves Millions," *Appliance Manufacturer*, Cahners Publishing Company, January 1986.

The author describes how decisions during design can save millions during assembly and production. Several examples are cited and the rules of design for assembly are listed.

Gallagher, C. C. and W. A. Knight, *Group Technology*, Butterworth and Co., London, 1973.

This work is contained in a recommended reading list for an advanced manufacturing curriculum at Auburn University.

Gansler, Jacques S., "Integrating Civilian and Military Industry," *Issues in Science and Technology*, pp. 68-73, Fall 1988.

The author argues for greater integration of military and civilian technologies at the engineering and production levels. He recommends five steps for DoD: (1) issue a specific policy statement; (2) identify and reduce existing barriers to integration; (3) develop a long-range strategy; (4) initiate a series of demonstration programs to work out many of the obstacles; and (5) assign specific organizational responsibilities.

Garvin, David A., "Competing on the Eight Dimensions of Quality," *Harvard Business Review*, pp. 101-109, November-December 1987.

The author describes eight dimensions of quality: performance, features, reliability, con-

formance, durability, serviceability, aesthetics, and perceived quality. He asserts that a company's challenge is to discover which dimensions of quality are most important for its business and product and to pursue those dimensions.

Garvin, David A., *Managing Quality*, The Free Press, New York, 1988.

The author provides an explication of the facets of quality and their role in the success of a company. This book presents one of the most detailed discussions of the different meanings of quality.

Garvin, David A., *Managing Quality–The Strategic and Competitive Edge*, The Free Press, New York, 1988.

The author provides an excellent treatment of the different definitions and dimensions of quality. A detailed case study drawn from the room air conditioner manufacturing industry is used to illustrate the author's views.

Gomory, Ralph E. and Harold T. Shapiro, "A Dialogue on Competitiveness," *Issues in Science and Technology*, pp. 36-42, Summer 1988.

This article is an edited transcript of the authors' discussion. A senior vice president for science and technology at IBM and president of Princeton University, they both lobby for greater directness, simplicity, and realism. They discuss the relationship between industry and the university and they agree that science and math aren't necessarily for everyone, but that basic literacy is a prerequisite for any advances.

Haas, Elizabeth A., "Breakthrough Manufacturing," *Harvard Business Review*, pp. 75-81, March-April 1987.

The author identifies the need for strategic focus. Instead of asking "How can we do it better?" we should ask "How can we beat the competition?" She discusses eight kinds of decisions: product design, process design, facility and plant configuration, information and control systems, human resources, research and development, suppliers' roles and relationships, organization.

Hahn, Gerald J., "The Coefficient of Determination Exposed!," *Chemical Technology*, vol. 3, No. 10, pp. 609-612, American Chemical Society, October 1973.

The author points out the problems of using R^2 to determine the goodness of a regression equation.

Hahn, Gerald J., "Don't Let Statistical Significance Fool You!," *Chemtech*, pp. 16-18, January 1974.

The author's column "Random Samplings" in CHEMTECH is a vehicle for providing practical advice on the uses and limits of statistics. Other columns appear in CHEMTECH issues in June and September of 1974, January, March, August, and September of 1975, February, March, May, August, and November of 1976, February, September, and October of 1977, March, May, and November of 1978, January, May, and August of 1979, January and June of 1980, February and March of 1981, May and December of 1982, May 1983, November 1984, March 1985, and July and June of 1987.

Hahn, Gerald J., "Some Things Engineers Should Know About Experimental Design," *Journal of Quality Technology*, vol. 9, No. 1, pp. 13-20, January 1977.

The author discusses basic considerations and practical aspects of designing and experiment.

Hahn, Gerald J., "Experimental Design in the Complex World," *Technometrics*, vol. 26, No. 1, pp. 19-31, February 1984.

The author discusses considerations other than selecting a matrix of experimental points

and analyzing the results.

Hall, Robert W., *Kawasaki U.S.A.: Transferring Japanese Production Methods to the United States–A Case Study,* American Production and Inventory Control Society, Inc., 1982.

This case study describes Dennis Butt's program to convert American job-shop type factory into a Japanese fast-flow factory.

Harrington, H. James, *Excellence-the IBM Way,* ASQC Quality Press, Milwaukee, 1988.

The author describes the techniques used at IBM to treat white collar tasks as processes that can become the subject of systematic quality improvement efforts.

Hauser, John R. and Don Clausing, "The House of Quality," *Harvard Business Review*, pp. 63-73, May-June 1988.

The authors describe the Quality Function Deployment (QFD) approach to subsystem design.

Hayes, Robert H., Steven C. Wheelwright, and Kim B. Clark, *Dynamic Manufacturing,* The Free Press, New York, 1988.

The authors present case studies that demonstrate the need for changes in manufacturing. Comprehensive coverage includes discussion of factors affecting management decisions to improve.

Hunter, J. Stuart, "The Technology of Quality," *RCA Engineer*, vol. 30-3, pp. 8-15, RCA Corporation, Princeton, NJ, May/June 1985.

The production of information-laden data is essential to the improvement of both product quality and process efficiency. The classical histogram and Shewhart chart are but two of many graphical devices for the study of historical data to secure quality improvement information. New information is also created through process and product design experimentation. Statistically designed experiments provide for the study of the influences of several factors varied simultaneously and can be used to "block" unwanted sources of variability. The language and tools of statistics are essential components to any learning process that involves the use of measurements. Industrial competitiveness requires the application of statistics in all of its modern modes.

Hunter, J. Stuart, "The Exponentially Weighted Moving Average," *Quality Technology*, vol. 18, No. 4, pp. 204-210, October 1986.

The author describes a technique for using data collected from a process to forecast future behavior of the process. The technique represents one of several improvements upon statistical process control techniques.

Hutchinson, Charles E. and Carol B. Muller, "Educating Engineers: In Praise of Diversity," *Issues in Science and Technology*, pp. 71-74, Summer 1988.

The authors discuss an National Research Council recommendation to have students pursue a liberal arts program during their first two years of college, and reserve the study of engineering for the last two years.

Ishikawa, Kaoru, *Guide to Quality Control,* Kraus International Publications, White Plains, NY, 1982.

The author describes the seven tools of quality control. He provides a description of a system that can be understood and implemented on the shop floor. (The seven tools are sometimes referred to as the seven old tools.)

Ishikawa, Kaoru, *What is Total Quality Control? The Japanese Way*, Prentice-Hall, Inc., Englewood Cliffs, 1985.

The author presents his views on why the Japanese have been so successful at implementing a quality approach to manufacturing.

Jiang, Bernard C., J. T. Black, and R. Duraisamy, "A Review of Recent Developments in Robot Metrology," *Journal of Manufacturing Systems*, vol. 7, No. 4, pp. 339-357.

This paper provides a review of various measurement techniques, and testing methods, conditions and specifications for determining the performance of robots.

Juran, J. M., *Quality Control Handbook*, McGraw-Hill, New York, 1962.

This work is a technical reference for many quality problems.

Jurgen, Ronald K., *Computers and Manufacturing Productivity*, IEEE Press, New York, 1986.

This book is a collection of articles that originally appeared in IEEE Spectrum. The articles are organized into seven areas: Part I, Productivity; Part II, Manufacturing's role in productivity; Part III, Data driven automation; Part IV, Implementing automation; Part V, Programmable logic controllers; Part VI, Robots to the rescue; and Part VII, The interface problem.

Kackar, Raghu N., "Off-Line Quality Control, Parameter Design, and the Taguchi Method," *Journal of Quality Technology*, vol. 17, No. 4, pp. 176-209, October 1985.

This paper introduces the concepts of off-line quality control and parameter design. The author also discusses the Taguchi Method for conducting parameter design experiments.

Kackar, Raghu N., "Taguchi's Quality Philosophy: Analysis and Commentary," *Quality Progress*, pp. 21-29, December 1986.

The author presents seven points that explain the basic elements of Taguchi's quality philosophy.

Kacker, Raghu N., "Quality Planning for Service Industries," *Quality Progress*, pp. 39-42, August 1988.

The author discusses steps for applying quality improvements within the service industries.

King, Bob, *Better Designs in Half the Time: Implementing QFD Quality Function Deployment in America*, GOAL/QPC, Methuen, MA, 1987.

The author provides detailed explanation of QFD with many charts. This could serve as a workbook for QFD implementation. The author uses Yoji Akao's version of QFD.

Knight, Donald O. and Michael L. Wall, "Using Group Technology For Improving Communication And Coordination Among Teams of Workers In Manufacturing Cells," *Industrial Engineering*, vol. 21, No. 1, pp. 28-34, Institute of Industrial Engineers, Norcross, GA, January 1989.

Group technology, a technique to identify families of parts that can be manufactured by similar operations, is applied to organizing planning and control functions for teams of workers who operate cell that are organized according to group technology.

Kurokawa, Kaneyuki, "Quality and Innovation," *IEEE Circuits and Devices*, pp. 3-8, July 1988.

The author points out the importance of communication with the customer and within an organization. Two concepts should govern the modern innovator: experimenting with real customers and graceful growth.

Kusaba, Ikuro, "Statistical Methods in Japanese Quality Control," *Societás Quálitátis*, vol. 2, No. 2, Union of Japanese Scientists and Engineers, May/June 1988.

The author reports methods and techniques whose use was reported at the Japanese quality circle conference. Author alludes to lack of reported use of Taguchi methods.

Landwehr, James M and Ann E. Watkins, *Exploring Data*, Dale Seymour Publications, Palo Alto, CA, 1987.

This book was prepared to help improve statistical literacy among junior- and senior-high students. The authors were guided by five principles: (1) There is often more than one way to approach problems in probability and statistics. (2) Real data should be used whenever possible. (3) Traditional topics taught in introductory statistics should be taught *after* the more basic ideas are understood. (4) The emphasis should be on good examples and teaching intuition. (5) Students enjoy and profit from project work and activities designed to give them practical experience in statistics.

Leon, Ramon V., Anne C. Shoemaker, and Raghu N. Kacker, "Performance Measures Independent of Adjustment: An Explanation and Extension of Taguchi's Signal-to-Noise Ratios," *Technometrics*, vol. 29, No. 3, pp. 253-285, American Statistical Association, August 1987.

The authors present an analysis of of Taguchi's signal-to-noise ratios including an explanation of when their use is justified and when it isn't. They introduce a term, performance measurement independent of adjustment (PerMIA), to replace S/N ratios.

Linn, Joseph L. and Robert I. Winner, *The Department of Defense Requirements for Engineering Information Systems*, IDA, Alexandria, VA, July 1986.

This two-volume requirements document describes the desired features of an Engineering Information System (EIS).

Marquardt, Donald W., "New Technical and Educational Directions for Managing Product Quality," *The American Statistician*, vol. 38, No. 1, pp. 8-14, February 1984.

This article explores the respective roles of business philosophy, management systems, and technology systems in attaining consistently higher product quality.

Marquardt, Donald W., "Meeting the Worldwide Quality Challenge," *Quality Progress*, pp. 34-37, August 1988.

The author traces three phases of quality awareness in the U.S. and asserts that four areas must be emphasized if U.S. industry is to succeed: commitment to excellence, international standards, supplier and customer partnerships, and improved candidness of communication.

Merchant, M. Eugene, *A Report to the National Science Foundation on Research Priorities for Proposed NSF Strategic Manufacturing Research Initiative*, National Science Foundation, Washington, DC, March 11-12, 1987.

The author describes a workshop where research priorities for NSF program were established. He presents the method used and lists 16 research topics in 6 broad areas.

Monden, Yasuhiro, *Toyota Production System*, Industrial Engineering and Management Press, Norcross, GA, 1983.

The author provides a detailed tutorial of the Toyota system, including Kanban.

Monden, Yasuhiro and et al., *Innovations in Management–The Japanese Corporation*, Industrial Engineering and Management Press, Norcross, GA, 1985.

This collection of articles describes Japanese management philosophy, strategies, organizational behavior, management control systems, Japanese human-resources management,

production management, total productive maintenance, factory automation, R&D, Japanese production management abroad, financial management, marketing, and foreign direct investment.

Monden, Yasuhiro, *Applying Just in Time: The American/Japanese Experience*, IIE Press, Norcross, GA, 1986.

This collection of papers describes "Just in time" production systems in Japan and in the U.S. and total quality control, total cost reduction, and total productive maintenance.

Montgomery, Douglas C., "Experiment Design and Product and Process Development," *Manufacturing Engineering*, pp. 57-63, September 1988.

The author provides an introductory overview of the use of experiment design techniques to improve the quality and cost characteristics of products. The author discusses briefly some of the main design of experiment techniques.

Morrow, Jeffrey A., *An Investigation of the Penetration of Taguchi Quality Engineering in Five U.S. Corporations*, June 1988.

Based on a master's thesis at MIT, this paper describes how Ford Motor Company, Davidson Rubber, AT&T, Xerox, and ITT adopted some of the Taguchi methods.

Nazaret, William A. and William Klingler, *Tuning Computer Systems for Maximum Performance: A Statistical Approach*.

The authors discuss the use of statistically designed experiments to improve the performance of the UNIX operating system on an AT&T Bell Laboratories computer.

NCMS, *1988 NCMS Research Agenda*, NCMS, April 21, 1988.

This planning document describes the most important research topics for the National Center for Manufacturing Science.

Nebeker, Delbert M, Brian M. Neuberger, and Vel N. Hulton, *Productivity Improvement in a Purchasing Division: Evaluation of a Performance Contingent Reward System (PCRS)*, Navy Personnel Research and Development Center, San Diego, CA, September 1983.

This report is one in a series concerned with the development, exploration, and generalization of a technique to increase individual motivation and productivity. The technique relies on applying behavioral science principles in what is termed a performance contingent reward system. The study evaluates the performance of small purchase buyers and supply clerks. The authors try to determine whether that performance would be enhanced by a PCRS.

Nemoto, Masao, *Total Quality Control for Management Strategies and Techniques from Toyota and Toyota Gosei*, Prentice Hall, Englewood Cliffs, NJ, 1987.

This book contains a translation of a series of lectures about the Toyota Gosei management philosophy and techniques. It includes a question and answer discussion of key topics.

Nussbaum, Bruce, "Smart Design, Quality is the New Style," *Business Week*, p. 102, April 11, 1988.

The author describes the trend towards including user and manufacturer considerations in design.

Packard, David, *A Quest for Excellence: Final Report to the President by the President's Blue Ribbon Commission on Defense Management*, U.S. Government Printing Office, Washington, DC, June 1986.

The study provides examples of excellence in the commercial sector and makes recom-

mendations about how to apply similar methods within the Department of Defense.

Page, E.S., "Continuous Inspection Schemes," *Biometrika*, vol. 41, pp. 100-115, 1954.

The author introduces the CUSUM chart, a technique that provides an alternative method of recording observations that helps to identify changes in a process mean.

Pao, T. W., M. S. Phadke, and C. S. Sherrerd, "Computer Response Time Optimization Using Orthogonal Array Experiments," *IEEE International Conference on Communications*, pp. 890-895, IEEE Communications Society, Chicago, IL, June 23-26, 1985.

The authors applied Taguchi techniques to systematically and efficiently optimize a system's performance under a specified range of load and environmental conditions. The system was a VAX 11-780 machine under UNIX SystemV Release 5.0 operation.

Parker, Mike and Jane Slaughter, "Management by Stress," *Technology Review*, pp. 37-44, October 1988.

The authors present an argument that the newer management techniques such as just-in-time and continuous improvement (Kaizen) are really a counterproductive form of management by stress and are actually methods for extracting "free" work out of the worker.

Pennar, Karen, "The Productivity Paradox," *Business Week*, pp. 100-102, June 6, 1988.

This is one of several articles in a special issue of Business Week that discussed productivity problems.

Pennell, James P., Len Haynes, and John Salasin, "A Proposed Architecture for Integrated Diagnostics," Presented at IEEE AUTOTESTCON 1988, October 1988.

The authors present an information architecture to support the integration of diagnostic concerns in the product realization process.

Pfau, Loren D., "Total Quality Management Gives Companies a Way to Enhance Position in Global Marketplace," *Industrial Engineering*, vol. 21, No. 4, pp. 17-21, April 1989.

The author provides an overview of TQM, its key concepts, role in a competitive strategy, and the changes needed to practice it.

Phadke, M. S. and et al., "Off-Line Quality Control in Integrated Circuit Fabrication Using Experimental Design," *AT&T Bell System Technical Journal*, vol. 62, No. 5, pp. 1273-1309, AT&T, May-June 1983.

The authors describe the application of design of experiments to a photolithography problem that resulted in a fourfold reduction in processing variation, a threefold reduction in fatal defects, and a twofold reduction in processing time.

Port, Otis, Resa King, and William J. Hampton, "How the New Math of Productivity Adds Up," *Business Week*, pp. 103-113, June 6, 1988.

This article examines some of the problems with accounting systems that are used today, how they measure and track the wrong parameters, and lead to the wrong investment and expenditure decisions.

Pugh, S., "Concept Selection–A Method that Works," *Proceedings I.C.E.D. WDK 5 Paper M3/16*, pp. 497-506, Rome, March 1981.

The author gives a description of a technique for comparing different concepts at the early design stage.

Phadke, Madhv S., *Quality Engineering Using Robust Design*, Prentice Hall, Englewood Cliffs, NJ, 1989.

The author provides an easy-to-understand, comprehensive discussion of the Taguchi approach to quality engineering. Beginning with a review of the concept of robust design, the book provides clear examples of the application of the principles of quality loss, quadratic loss, noise factors, exploiting nonlinearity, matrix experiments. This is one of the clearest books for someone who is interested in using the Taguchi approach for achieving robust design.

Riedel, James A. and et al., *Designing a Group Wage Incentive System for Shipyard Production Employees,* Navy Personnel Research and Development Center, San Diego, CA, May 1987.

This report describes the process and results of designing a group wage incentive system for production workers at a naval shipyard. The system provides periodic cash awards to groups of civil-service workers performing above the standard. Key features of the organizational setting that were considered in the design of these systems are discussed.

Rohlen, Thomas P., "Why Japanese Education Works," *Harvard Business Review,* pp. 42-47, September-October 1987.

The author reviews two books about Japanese education: *The Japanese School: Lessons for Industrial America*, by Benjamin Duke, Praeger, 1986; and *The Japanese Educational Challenge: A Commitment to Children*, by Merry White, Free Press, 1987. The reviewer notes that both books show superb human resources are the foundation of Japanese success and those resources are the product of and educational system which reflects Japan's commitment to learning.

Rome Air Development Center, *A Guide for Government Program Managers: How You can Acquire and Deploy and Improved Weapon System Diagnostic Capability,* Giordano Associates Inc., Sparta, NJ, 1988.

This handbook is designed to help program managers ensure that concerns for diagnostic capabilities of weapons systems are addressed early in the development cycle.

Russell, G., *Computer-Aided Tools for VLSI System Design,* Peter Peregrinus Ltd., London, 1987.

This is a collection of papers from researchers in UK describing a CAD overview, circuit simulation, logic simulation, testing, autolayout, symbolic design of VLSI circuits, IC layout verification, high-level design languages, PLA design tools, silicon compilation, CAD systems, data management, and verification of systems.

Schmidt, Stephen R. and Roger Launsby, *Understanding Industrial Designed Experiments,* CQD Ltd. Printing, Longmont, CO, 1988.

The authors designed a handbook for the engineer who has decided to start using orthogonal or nearly orthogonal experimental designs.

Schonberger, R. J., *Japanese Manufacturing Techniques,* The Free Press, 1982.

This book is recommended as part of the reading list for the Auburn University advanced program in manufacturing sciences.

Schonberger, Richard J., *World Class Manufacturing,* Free Press, New York, 1987.

The author presents an overview of Japanese manufacturing techniques and American examples of just-in-time (JIT) manufacturing.

Schreiber, Rita R., "Design for Assembly," *Robotics Today,* pp. 45-46, June 1985.

The author relates the view of Gordon Lewis, engineering consultant at Xerox, including his view of the need for a two-stage process: developing a set of principles to aid the product development team and the formation of a design for assembly team to evaluate the design and point out improvements.

Scott, Bruce R. and et. al., "Competitiveness: 23 Leaders Speak Out," *Harvard Business Review,* pp. 106-123, July-August 1987.

This article provides responses to an HBR survey on competitiveness.

Seifert, Laurence C., "Design and Analysis of Integrated Electronics Manufacturing Systems," *Design and Analysis of Integrated Manufacturing Systems*, pp. 12-33, National Academy Press, 1988.

The author describes AT&T efforts to improve quality and productivity at Oklahoma City and Denver locations.

Sepehri, Mehran, *Quest for Quality: Managing the Total System*, Industrial Engineering and Management Press, Atlanta, GA, 1987.

This is a collection of articles with chapters entitled, "Toward World Class Quality," "Defining Quality," "Managing Quality," "Education," "Training and Quality Circles," "Tools," "The Service Sector," "Cost," "Quality Through Automation," "Software," and "Case Studies."

Sequin, Carlo H., "Managing VLSI Complexity: An Outlook," *Proceedings of the IEEE*, vol. No. 1, pp. 149-166, IEEE, January 1983.

The author examines the nature of complexity of VLSI circuits and shows similarity with large software engineering problems.

Shingo, S., *A Revolution in Manufacturing: The SMED System*, Productivity Press, 1985.

Not reviewed by the authors, this book is part of a recommended reading list for the Auburn advanced manufacturing studies program.

Shoemaker, Anne C. and Raghu N. Kacker, "A Methodology for Planning Experiments in Robust Product and Process Design," *Quality and Reliability Engineering International*, vol. 4, pp. 95-113, John Wiley & Sons, 1988.

The authors describe a four-step method for implementing robust design: (1) formulate the problem by stating the objectives and then listing and classifying product and process variables; (2) plan an experiment to study these variables; (3) identify improved settings of controllable variables from the experiment's results; and (4) confirm the improvement with a small follow-up experiment.

Snee, Ronald D., "Experimenting with Mixtures," *Chemtech*, vol. 9, pp. 702-710, November 1979.

The author discusses design of experiments for mixture problems and shows that the factorial design is not suitable for this situation. He describes the simplex approach and gives examples of different models for fitting a response surface.

Snee, Ronald D., "Graphical Analysis of Process Variation Studies," *Journal of Quality Technology*, vol. 15, No. 2, pp. 76-88, April 1983.

Graphical procedures for analyzing the results of nested sampling studies are presented and illustrated with examples. It is shown that a standard deviation control chart analysis will detect atypical results and nonhomogeneous variances that can greatly distort the estimated process variance components. The procedure enables the quality engineer to see the sources and magnitude of the variation in the process and to identify any unusual characteristics of the data.

Snee, Ronald D., Lynne B. Hare, and J. Richard Trout, *Experiments in Industry: Design, Analysis, and Interpretation of Results*, American Society for Quality Control, Milwaukee, WI, 1985.

This collection of papers on industrial experiments from Swift and Company, E.I. du Pont de Nemours and Company, Manville Corporation, General Electric, Rutgers University, Environmental Protection Agency, Thomas J, Lipton Inc., United States Steel, Procter and Gamble, and Colorado State University gives many examples of statistical experiments in practical applications.

Snee, Ronald D., "Computer-Aided Design of Experiments–Some Practical Experiences," *Journal of Quality Technology*, vol. 17, No. 4, pp. 222-236, October 1985.

The author describes uses of computers to administer experimental programs and to develop experimental plans for situations where classical methods are not applicable. Several examples are presented.

Snodgrass, Thomas J. and Muthiah Kase, *Function Analysis: The Stepping Stones to Good Value*, Board of Regents–University of Wisconsin System, Madison, WI, 1986.

The authors provide a description of the *FAST* function analysis system technique including technical FAST, Task/Customer FAST, and function cost allocation as part of Value Engineering. There are some similarities in the goals of FAST and QFD but the implementations are different. At least one practitioner found them complementary.

Sullivan, L. P., "Quality Function Deployment," *Quality Progress*, pp. 39-50, June 1986.

The author provides an introduction to QFD.

Suzaki, Kioyoshi, *The New Manufacturing Challenge*, The Free Press, 1987.

Not reviewed by the authors, this book is part of a recommended reading list for the Auburn advanced manufacturing studies program.

Taguchi, G. and S. Konishi, *Orthogonal Arrays and Linear Graphs*, American Supplier Institute, Dearborn, MI, 1987.

This booklet contains the most commonly used orthogonal arrays and their associated linear graphs.

Taguchi, Genichi and Yuin Wu, *Introduction to Off-Line Quality Control*, Central Japan Quality Control Association, February 1, 1985.

This tutorial is available from the American Supplier Institute, Dearborn, MI. As the title suggests, it is an introduction to the quality philosophy of Genichi Taguchi.

Taguchi, Genichi, *Introduction to Quality Engineering*, American Supplier Institute, Dearborn, MI, 1986.

This is another introductory text on Taguchi's quality engineering methods.

Taguchi, Genichi, *System of Experimental Design*, American Supplier Institute, Detroit, MI, 1988.

Taguchi describes his recommended methods for experimental design.

Talley, Dorsey J., "New Challenges for Quality Professionals in Defense Industries," *Quality Progress*, vol. XXI, Number 12, pp. 41-43, ASQC, Milwaukee, December 1988.

The author, a division vice president for quality assurance with General Dynamics discusses the DoD quality excellence program, the concerns of industry, and the objectives for quality professionals. He mentions the DoD Ten Point Excellence Program and describes how General Dynamics is responding to the challenges of the program. The author pays particular attention to specification streamlining, new specifications and clauses (e.g., AVIP) new interpretations (a cause for concern), and the role of audits as cost drivers.

Tribus, Myron, *Quality First: Selected Papers on Quality and Productivity Improvement*, National Society of Professional Engineers, Washington, DC, March 1988.

The author presents fifteen essays on productivity, competitiveness, management, Deming management philosophy, and quality.

Tribus, Myron, "Changing the Corporate Culture Some Rules and Tools," Presented to the Philadelphia Area Council on Excellence, Valley Forge, PA, October 17, 1988

This is a plan for changing a corporation so that it becomes a winner. It includes descriptions of the following: (1) the principles for changing the culture, (2) the features of "World Class" companies, (3) the role of a manager as an agent of change, (4) a plan for education, (5) how to make a flow chart for a process, (6) techniques for involving employees in system improvement, and (6) a strategy for leading the change.

Tsui, Kwok-Leung, "Strategies for Planning Experiments Using Orthogonal Arrays and Confounding Tables," *Quality and Reliability Engineering International*, vol. 4, pp. 113-122, John Wiley & Sons, January 1988.

The author presents a new set of tools, "confounding tables" for use by experimenters when planning experiments. The tables are compared with Taguchi's linear graphs.

United States Air Force, *USAF R&M 2000 Process*, Headquarters, United States Air Force Office of the Special Assistant for R&M, Washington, DC, October 1987.

This document describes R&M 2000 goals, principles, and building blocks to increase combat capability while saving resources through good R&M practices.

Wheeler, Donald J. and David S. Chambers, *Understanding Statistical Process Control*, Statistical Process Controls Inc., Knoxville, TN, 1986.

The authors provide a tutorial on how to set up control charts for various situations.

Whitney, Daniel E. and et al., "The Strategic Approach to Product Design," *Design and Analysis of Integrated Manufacturing Systems*, pp. 200-223, National Academy Press, Washington, DC, 1988.

The authors describe a concurrent design approach developed at Draper Labs that focuses on the assembly process.

Willoughby, W. J., *Best Practices: How to Avoid Surprises in the World's Most Complicated Technical Environment*, Department of the Navy, Washington, DC, March 1986.

This is a supplement to DOD 4245.7 that enhances the enlightenment of industry and government by identifying specific practices in current use and their potential adverse consequences in terms of cost, schedule, performance, and readiness. It then describes the proven best practices which avoid or alleviate these consequences and provides enough background rationale to understand them.

Winner, Robert I. and et al., *The Role of Concurrent Engineering in Weapons System Acquisition*, DTIC AD-A203 615, Alexandria, VA, December 1988.

This report documents the results of an IDA study on concurrent engineering and provides recommendations for a DOD policy to include concurrent engineering in the acquisition process.

Wolfe, Robert, "Solid Modeling for Production Design," *IBM Journal of R&D*, IBM, Yorktown Heights, May 1987.

The author describes use of solid modeling for both mechanical and semiconductor design and evaluation. He describes a system for mechanical applications and one for semiconductor applications.

Woodward, R. H. and P. L. Foldsmith, *Cumulative Sum Techniques*, Oliver & Boyd, London, 1964.

The authors describe and explain cumulative sum (CUSUM) techniques.

Distribution List for IDA Document D-571

NAME AND ADDRESS	NUMBER OF COPIES
Sponsor	
Mr. Marty Meth Director, WSIG OASD(P&L) Room 2B322 The Pentagon Washington, DC 20301	2
Col Tim Neel Defense Systems and Programs Office Defense Logistics Agency Cameron Station Alexandria, VA 22314	5
Other	
Defense Technical Information Center Cameron Station Alexandria, VA 22314	2
Mr. Karl H. Shingler Department of the Air Force Software Engineering Institute Joint Program Office (ESD) Carnegie Mellon University Pittsburgh, PA 15213-3890	1
Mr. Robert D. Aaron DoD Product Engineering Services Office c/o Defense Logistics Agency Cameron Station Alexandria, VA 22304-6183	1
Mr. John Alber Section Head, ILS Systems Engineering Grumman Aircraft Systems MS C05-106 Bethpage, NY 11714	1
Mr. D.M. Altwegg 2531 Jefferson Davis Highway National Center 3 Room 11S18 Arlington, VA 22202	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Gary Ammerman Operations Manager Ballistic Systems Division Boeing Aerospace P.O. Box 3999, MS 3J-74 Seattle, WA 98124-2499	1
Mr. W.B. Anderson, Jr. Director Support Requirements & Systems General Dynamics, Fort Worth Division Grants Lane Box 748, Mail Zone 2467 Fort Worth, TX 76101	1
Mr. Joe Arcieri DSPO Suite #306 5109 Leesburg Pike Falls Church, Virginia 22142	1
Dr. Steve P. Bailey E.I. Dupont de Nemours & Co. Engineering Department P.O. box 6090 Newark, DE 19714	1
Mr. William G. Beazley Editor and Publisher Knowledge Base International 13939 Northwest Freeway Suite 270 Houston, TX 77040 (713) 690-7644	1
Thomas H. Bennett General Dynamics Mail Zone 2826 P.O. Box 748 Fort Worth, Texas 76101	1
Dr. Charles Bernstein Northrop Corporation 1840 Century Park East Los Angeles, CA 90067	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Howard Bloom National Institute of Standards and Technology Bldg. 220, Room A 127 Gaithersburg, MD 20899	1
Mr. Kenneth Blum Manager of Quality Directorate Hughes Aircraft Company Electro-Optical and Data Systems Group Bldg. E-8 M/S G 189 P.O. Box 902 El Segundo, CA 90245	1
Prof. G. Boothroyd Industrial & Manufacturing Engineering Dept. University of Rhode Island Kingston, RI 02881	1
Dr. George Box University of Wisconsin at Madison Center for Quality and Productivity Improvement 610 Walnut Madison, WI 53705	1
Mr. Robert E. Boykin III Program Manager Computer Aided Mfg. -Intl. Inc. 1250 E. Copeland Road, Suite 500 Arlington, TX 76011	1
Ms. Laurie Broedling Code 16 NPRDC San Diego, CA 92152	1
Mr. Peter F. Brown National Institute of Standards and Technology Building 220, Room A-127 Gaithersburg, MD 20899	1
Professor G. Rex Bryce Brigham Young University Provo, Utah 84602	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Roger Burkhart Manager Software Tech Group Deere Tech Services John Deere Road Moline, IL 61265	1
Dr. R.P. Caren Chief Scientist Lockheed Corporation 4500 Park Granada Blvd. Calabasas, CA 91399	1
Mr. Kidar Chadha Northrop Corporation Aircraft Division Dept. 3320/82 1 Northrop Avenue Hawthorne, CA 90250	1
Mr. Thomas Christie Director, Program Integration Rm 3E1034 The Pentagon Washington, DC 20301	1
Mr. David Chu Assistant Secretary of Defense Program Analysis and Evaluation Rm 3E836 The Pentagon Washington, DC 20301	1
Mr. Ralph D. Clark TRW, BLDG E-2 MS 5061 1 Space Park Redondo Beach, CA 90278	1
Dr. Don Clausing Massachusetts Institute of Technology Laboratory for Manufacturing & Productivity Bldg. 35, Rm. 238 77 Massachusetts Avenue Cambridge, MA 02139	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Peter Cofoni TASC 1700 N. Moore Street Suite 1800 Arlington, VA 22209	1
Mr. Thomas Cook M/S S307A, Sikorsky Aircraft 6900 Main St. Stratford, CT 06601-1381	1
Dr. John Coppola Assistant to the President Standard Oil Engineered Materials Co. P.O. Box 156 Niagara Falls, N.Y. 14302	1
Mr. Harold Croy Ballistic Systems Division Boeing Aerospace P.O. Box 3999, MS 3J-74 Seattle, WA 98124-2499	1
Ms.Ann Dare IBM Corp. Department C-12, Bldg. 703 Poughkeepsie, NY 12602	1
Dr. Thomas L. DeFazio C.S. Draper Laboratory 555 Technology Square, MS1E Cambridge, MA 02139	1
Dr. Jean-Pierre DeJean General Electric A/C Engines N202 55 Merchant Street Cincinnati, OH 45215	1
Mr. Gary Denman AFWAL/CD Wright Patterson AFB, OH 45433	1

NAME AND ADDRESS	NUMBER OF COPIES
Prof. P. Dewhurst Industrial & Manufacturing Engineering Dept University of Rhode Island Kingston, RI 02881	1
Prof. John Dixon University of Massachusetts Amherst, MA	1
Mr. Donald Duboise Northrop Advanced Systems Division 8900 E. Washington Blvd. Pico Rivera, CA 90660	1
Mr. James J. Duhig Chief Engineer, Supportability Lockheed Aeronautical Systems Company Department 7201, Zone 6 Marietta, GA 30063	1
Mr. Keith Durfee Manager of System Packaging Design IBM Dept. C15, Bldg. 703 Poughkeepsie, NY 12601	1
Mr. Scott Duvall Pratt & Whitney 400 Main Street MS 165-35 E. Hartford, CT 06108	1
Mr. John Early Juran Institute, Inc. 88 Danbury Road. Wilton, CN 06897	1
Mr. Perley Eaton TRW Federal Systems Group One Federal Systems Park Drive 12900 Fair Lakes Parkway Fairfax, Virginia 22033	1
Mr. Alexander C. Edsall C.S. Draper Laboratory 555 Technology Square, MS1E Cambridge, MA 02139	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Mike Elem Director Systems Engineering Grumman Aircraft Systems Bethpage, NY 11714	1
Mr. D. Travis Engen Senior Vice President, ITT President & Chief Executive Officer ITT Defense Technology Corporation 1000 Wilson Blvd. Arlington, VA 22209 Attn. Ms. Sheila Ball	1
Mr. Gordon England General Dynamics Land Division 38500 Mound Road Sterling Heights, MI 48310-3268	1
Dr. Joseph W. Erkes GE Corporate R&D P.O. Box 8, Bldg. KWD/244 Schenectady, NY 12301	1
Mr. Robert Estrada Program Manager, VHSIC IBM, Federal Systems Division 9500 Godwin Drive Manassas, VA 22110	1
Mr. Richard P. Eynon Martin Marietta Electronics and Missiles Group P.O. Box 5837 MP126 Orlando, FL 32855	1
Mr. Wayne D. Fegely Executive Director, Systems Development Westinghouse Electric Corporation MS 1107 Elkridge Landing Road Linthicum, MD 21090	1
Dr. Susan Finger Carnegie-Mellon University The Robotics Institute Pittsburgh, PA 15213	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Hans Forsch Grumman Corp. MS B-37-35 Plant 35 Bethpage, NY 11714-3580	1
Dr. Mark Fox Carnegie-Mellon University The Robotics Institute Pittsburgh, PA 15213	1
Mr. Al Frager Information Spectrum, Inc. 1745 Jeff Davis Hwy. Suite 500 Arlington, VA 22202	1
Mr. Richard Franseen AMCDE-HE 5001 Eisenhower Avenue Alexandria, VA 22333	1
Mr. Donald Fredericksen DUSD Tactical Warfare Programs Room 3E1044 The Pentagon Washington, DC 20301	1
Mr. Paul Frey Search Technology Inc. 4725 Peachtree Corners Circle Suite 200 Norcross, GA 30092	1
Dr. Alan W. Fulton AT&T Room 2F132 1100 E. Warrenville Road Naperville, IL 60566	1
Dr. Conrad Fung University of Wisconsin at Madison Center for Quality and Productivity Improvement 610 Walnut Madison, WI 53705	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Jacques Gansler Analytic Science Corp. 1700 N. Moore Street Suite 1220 Arlington, VA 22209	1
D.W. George General Dynamics P.O. Box 85310 San Diego, California 92138	1
Mr. Siegfried Goldstein P.O. Box 2308 N. Babylon, New York 11703	1
Dr. G.D. Goldshine Advanced Manufacturing Engineering General Dynamics Pomona Division P.O. Box 2507 Pomona, CA 91769-2507	1
BGen. Frank S. Goodell HQ USAF/LE-RD Washington, DC 20330	1
Dr. Istvan Gorog Director Manufacturing Technology Research Laboratory David Sarnoff Research Center, SRI 201 Washington Road Princeton, NJ 08540	1
Dr. David Gossard Mechanical Engineering Dept. MIT 77 Massachusetts Avenue Bldg. 3-449 or 3-458 Cambridge, MA 02139	1
Mr. Arlen Green Manager, Quality Improvement Bell Helicopter Textron P.O. Box 482 Ft. Worth, TX 76101	1

NAME AND ADDRESS	NUMBER OF COPIES
Col. Joseph S. Greene, Jr. DARPA/DMO 1400 Wilson Boulevard Arlington, VA 22209-2308	1
Mr. George Gregurec Director Program Product Support- New Aircraft Products McDonnell Aircraft Company Dept. 90, Bldg.61B Room 167 P.O. Box 516 St. Louis, MO 63166	1
Mr. Darold Griffin Army Materiel Command Rm 9E22 5001 Eisenhower Avenue Alexandria, Virginia 22333-0001	1
Mr. Richard E. Gustavson C.S. Draper Laboratory 555 Technology Square, MS1E Cambridge, MA 02139	1
Dr. G. J. Hahn Receiving Dock General Electric Corporate Research and Development River Road Schnectady, NY 12301 (Attn. Dr. G.J. Hahn, K1-4C33)	1
Mr. Don Hall OASD CP&LS WS Room 2B322 The Pentagon Washington, D.C. 20301	1
Mr. William Hallisey SD/CLH ALS Program Office P.O. Box 92960 Los Angeles, CA 90009-2960	1
Dr. John Halpin ASD/EN (PA) Wright Patterson AFB, OH 45433	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Nick Handres Manager Industrial Business Development Electronic Data Systems Pinehurst Building 1400 North Woodward Avenue Bloomfield Hills, MI 48013	1
Mr. Bill Haney Texas Instruments 6500 Chase Oaks Blvd. P.O. Box 869305, MS 8408 Plano, TX 75086	1
Dr. Leo Hanifin Director Center for Manufacturing Productivity Rensselaer Polytechnic Institute 110 8th Street Troy, NY 12180-3590	1
Dr. John Hanne MCC-Austin 3500 W. Balcones Cts. Drive Austin, TX 78759	1
Prof. Martin Hardwick Computer for Mfg. Productivity Rensselaer Polytechnic Institute 110 8th Street Troy, NY 12181	1
Mr. Darrell Harrison AMCPEO-LHX 4300 Goodfellow Blvd. St. Louis, MO 63120	1
Mr. Leroy Haugh A1A 1250 Eye Street, N.W. Washington, D.C. 20005	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. John Hennessey Allied-Signal Aerospace Company Garrett Engine Division 111 South 34th Street P.O. Box 5217 MS 93-030/503-1P Phoenix, AZ 85010	1
Mr. Bill Henry Boeing Aerospace P.O. Box 3999, MS 9Y-19 Seattle, WA 98124	1
Mr. Al Herner AFWAL/MTC Wright-Patterson AFB Ohio 45433	1
Dr. Richard Hildebrant C.S. Draper Laboratory 555 Technology Square, MS 3B Cambridge, MA 02139	1
Dr. John Hines AFWAL/AADE-3 Wright Patterson AFB, OH 45433	1
Mr. Kenneth Hinman ADUSD Air Warfare 3E1081 The Pentagon Washington, DC 20301	1
Mr. Dennis Hoffman Texas Instruments Inc./DSEG P.O. Box 869305, M/S 8506 Plano, Texas 75086	1
Dr. Robert Hogg Department of Statistics University of Iowa Iowa City, Iowa 50042	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. Theodore H. Hopp National Institute of Standards and Technology Bldg. 220, Room A-127 Gaithersburg, MD 20899	1
Mr. L.M. Horner President Bell Helicopter Textron P.O. Box 482 Ft. Worth, TX 76101	1
Mr. William C. Huber NASA JSC KC3 Mail Code KC-311 Houston, TX 77058	1
Mr. James N. Hughes Production Resources Operation General Electric Company 1285 Boston Avenue, Bldg. 28EE Bridgeport, CT 06602	1
Mr. Bob Hume NAVAIR Room 902 Crystal Gateway I Washington, DC 20361	1
Mr. Dan Hunt Technology Research Corp. Springfield Professional Park 8328 Traford Lane Suite A Springfield, VA 2215	1
Dr. Stu Hunter Princeton University 530 Lake Drive Princeton, N.J. 08540	1
Mr. Mike Hurn Texas Instruments 6500 Chase Oaks Blvd. P.O. Box 869305, MS 8408 Plano, TX 75086	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. William E. Isler DARPA/ISTO 1400 Wilson Blvd. Arlington, VA 22209	1
Mr. Edwin J. Istvan Senior Associate The Pymatuning Group Inc. Suite 707 2000 N. 15th Street Arlington, VA 22201	1
Mr. Dick Jamison Program Manager, Radar Systems Group Hughes Aircraft Company Building R-7, Mail Stop 1114 Box 92426 Los Angeles, CA 90009	1
Capt Bruce Johnson HQ USAF/LE-RD The Pentagon Washington, DC 20330	1
Mr. James C. Jones Computer Aided Manufacturing HUGHES Radar Systems Group P.O. Box 92426 Bldg. R35, MS 1602 Los Angeles, CA 90009	1
Mr. Rod Julkowski Honeywell, Inc. 12001 Highway 55 (MN14-4C15) Plymouth, MN 55441	1
Dr. Raghu Kacker National Institute of Standards and Technology Room A-337 The Administration Building Gaithersburg, MD 20899	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Gordon Keefe Association of Defense Suppliers 1940 Holland Cliff Road Huntington, MD 20639	1
Mr. Grant Keller 11357 Charnock Road Los Angeles, CA 90066	1
Dr. Clinton W. Kelly III Corporate Vice President Science Applications International Corp. 1710 Goodridge Drive McLean, VA 22102	1
Dr. Michael Kelly DARPA-DMO 1400 Wilson Boulevard Arlington, VA 22209-2308	1
Mr. Patrick J. Kelly Director Advanced Programs McDonnell Douglas Astronautics, Co. Saint Louis Division P.O. 516 St. Louis, MO 63166-0516	1
Dr. Ranga Komanduri Acting Div. Director/DMCE National Science Foundation 1800 G. Street, N.W. Washington, D.C. 20550	1
Dr. James Kowalick Director Productivity & Quality Improvement (Taguchi/QFD/SPC Consultant) Aerojet Ordnance Co. 9236 East Hall Road Downey, CA 90241	1
Mr. Bill Kracov 1121 University Blvd. West Wheaton, MD 20902	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. George H. Kuper National Research Council National Academy of Sciences 2101 Constitution Avenue, NW Washington, DC 20418	1
Mr. Mike Kutcher IBM Corp. MS 584 Kingston, NY 12401	1
Mr. Loren Lammerman Chief Engineer, Systems Engineering Lockheed Aeronautical Systems Company P.O. Box 551 Burbank, CA 91520	1
Mr. Paul R. Lange Vice President, Integrated Logistics Support Northrop Corporation One Northrop Avenue, Dept 8800/76 Hawthorne, CA 90250	1
Dr. Noshir Langrana Caip Center Rutgers University Piscataway, N.J. 08855-1390	1
Mr. Larry A. Lemke Vice President General Manager, MD-80 Program McDonnell Aircraft Company M/S C1M80 (138-31) 3855 Lakewood Blvd. Long Beach, CA 90846	1
Dr. J.W. Lewis GE Corporate R&D P.O. Box 8, KWD 244 Schenectady, NY 12301	1
Mr. Paul Lin American Supplier Institute Six Parklane Blvd. (Suite 411) Dearborne, MI 48126	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. C. Dale Little Engineering Program Manager General Dynamics P.O. Box 748 Mail Zone 2160 Fort Worth, TX 76101	1
Mr. Larry Linton Litton, Amecom 5115 Calvert Road College Park, MD 20740-3898	1
Mr. R. Noel Longuemare Vice President and General Manager Development and Operations Division Westinghouse Electric Corp. Electronic Systems Group Box 1693 Baltimore, MD 21230	1
Mr. Dick Lopatka Pratt & Whitney MS 165-35 400 Main Street East Hartford, CT 06108	1
Mr. Si Lorber Army Materiel Command Rm 4W22 5001 Eisenhower Ave. Alexandria, Virginia 22333-0001	1
Dr. Manuel E. Lores Director, Aircraft Technology Dept. 01-35, Bldg 63-2 Plant A-1 P.O. Box 551 Lockheed Aeronautical Systems Burbank, CA 91520-01-35	1
Mr. Al Lowenstein Prospective Computer Analysts 1800 Northern Blvd. Roslyn, NY 11576	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. Robert Lundegard National Institute of Standards and Technology Administration Building Gaithersburg, MD 20899	1
Mr. Ervin Maki Westinghouse Electric Corp. MS 1107 P.O. Box 1693 Baltimore, MD 21203	1
Dr. Steven Maslen Martin Marietta Labs. 1450 South Rolling Road Baltimore, MD 21227	1
Dr. George Mayer Insitute for Defense Analyses 1801 N. Beauregard Street Alexandria, VA 22311	1
Ms. Naomi McAfee Director Reliability, Maintainability & Supportability Westinghouse Electric Corp. P.O. Box 1693, MS 1105 Baltimore, MD 21203	1
Mr. Donald P. McConnell Senior Vice President Engineering and Manufacturing Technology Columbus Division, BATELLE 505 King Avenue Columbus, OH 43201-2693	1
Mr. Robert C. McCormack DASD (Production Support) Room 3E144 The Pentagon Washington, DC 20301	1
Mr. Thomas B. McDavitt Boeing Military Airplanes P.O. Box 7730 Wichita, KA 67277-7330	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. Gary McDonald Head, Mathematics Department General Motors Research Laboratory 30500 Mound Road Warren, MI 48090-9055	1
Dr. Michael F. McGrath Office of the Secretary of Defense OASD(P&L)-CALS Room 2B322, The Pentagon Washington, D.C. 20301-800	1
Mr. Keith McKee Director ITRI Manufacturing Productivity Center 10 West 35th Street Chicago, IL 60616	1
Dr. Barry W. McNeill Mech. & Aero. Engineering Arizona State University Tempe, AZ 85287	1
Mr. Randy Meeker HQ AFSC/XTXC Andrews AFB, DC 20334-5000	1
Mr. Vern Menker ASD/EN (PA) Wright Patterson AFB, OH 45433	1
Mr. Joe Meredith Newport News Shipbuilding Co. Suite 1100 2711 S. Jefferson Davis Highway Arlington, VA 22202	1
Mr. Richard W. Metzinger C.S. Draper Laboratory 555 Technology Square, MS1E Cambridge, MA 02139	1
Mr. Stan Meyer Grumman Data Systems M/S D20-237 1000 Woodbury Road Woodbury, NY 11797	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Steve Meyer McDonald Douglas Helicopter 500 East McDowell Road Building 530-B220 Mesa, AZ 85205	1
Mr. Wendell Meyer Martin Marietta Orlando Aerospace P.O. Box 5837, MP 150 Orlando, FL 32855	1
Dr. George P. Millburn Deputy Under Secretary R&AT Rm 3E114 The Pentagon Washington, DC 20301	1
Dr. David Milgram Advanced Decision Systems 1500 Plymouth Street Mountain View, CA 94043	1
Mr. Stuart G. Miller General Electric KWD 227, P.O. Box 8 Corporate Research & Development Schenectady, NY 12301	1
Mr. Edward Miyashiro General Dynamics Pomona Division P.O. Box 2507 Pomona, CA 91769-2507	1
Mr. Niel Monroe Government Computer News 8601 Georgia Avenue Suite 300 Silver Spring, MD 20910	1
Mr. J.W. Moore IBM Systems Integration Division 18100 Frederick Pike, 182/3G94 Gaithersburg, MD 20879	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. Willie Hobbs Moore Ford Motor Co. Room 524 American Road Dearborn, MI 48121	1
Mr. Roger Morenc SDRC 2000 Eastman Drive Milford, OH 45150	1
Mr. Lloyd Mosemann SAF/RL Rm 4D865 The Pentagon Washington, DC 20301	1
Mr. Dennis Mueller Northrop Advanced Systems Division 8900 E. Washington Blvd. Pico Rivera, CA 90660	1
Mr. Thomas J. Murrin Distinguished Service Professor of Technology and Management Carnegie Mellon University 4630 Wean Hall Pittsburg, PA 15213-3890	1
Mr. Thomas Musson SIGMA PLUS, Inc. 4001 Williamsburg Court Fairfax, Virginia 22032	1
1LT Nick Naclerio AFWAL/AADE-3 Wright Patterson AFB, OH 45433-6543	1
Dr. James Naughton Expert-Knowledge Systems Inc. 1428 Buena Vista Avenue McLean, VA 22101	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. M. Dean Nelsen Vice President, Operations Boeing Military Airplane Company 3801 S. Oliver MSK 15-44 Box 7730 Wichita, KS 67277-7730	1
Mr. Daniel Neff Deere Tech Services John Deere Road Moline, IL 61265	1
Mr. Jim Nevins Division Leader, Robotics and Assembly Systems Division Charles Stark Draper Laboratory 555 Technology Square Cambridge, MA 02139	1
Mr. Herb W. Nidenberg Vice President, Manufacturing Systems & Technology Columbus Division, BATELLE 505 King Avenue Columbus, OH 43201-2693	1
Mr. Brad Novic Technical Supervisor Applied Statistics Group ALCOA Technical Center AMCT-D Alcoa Center, PA 15069	1
Mr. Ronald C. Olson P-3 Update 4 Program Manager Boeing Aerospace P.O. Box 3999, M/S 2F-05 Seattle, WA 98124-2499	1
Mr. Archie Ossin MP 150 Martin Marietta Missile Systems P.O. Box 5837 Orlando, FL 32855-5837	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. Phil Parrish DARPA/ISTO 1400 Wilson Blvd. Arlington, VA 22209	1
Mr. Tom Parry DSPO Suite #306 5109 Leesburg Pike Falls Church, Virginia 22142	1
Mr. Larry Patrick Business Development Technology Development Unit D. Appleton Company 4001 West Airport Freeway Suite 390 Bedford, TX 76021	1
Mr. Doug Patterson OASN (S&L) RM & AQ Room 362 Crystal Plaza 5 Washington, DC 20360-5000	1
Mr. Mike Patterson Office of the Assistant Secretary of the Army for Research, Development & Acquisition Rm 2E673 The Pentagon Washington, DC 20301	1
Dr. Michael Pecht University of Maryland Engineering Research Center College Park, Maryland 20742	1
Dr. Thomas J. Peters C.S. Draper Laboratory 555 Technology Square, MS1E Cambridge, MA 02139	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Edward Petrushka Vice President Research and Engineering General Dynamics Fort Worth Division P.O. Box 748, M/S 2899 Fort Worth, TX 76101	1
Mr. Troy E. Pfannkuche Assistant Program Manager F-15 Program Division Radar Systems Group P.O. Box 92426 Bldg. R7, MS1114 Los Angeles, CA 90009	1
Dr. Madhav Phadke AT&T Bell Laboratories Room No. HO 2J510 Holmdel, NJ 07733	1
Mr. Roland Piepenbrink NSWSES (Navy) Code 5H10 Port Huememe, CA 93043-5007	1
Mr. Martin Plawsky Manager Logistics R&D Grumman Aircraft Systems Bethpage, NY 11714-3582	1
Mrs. Kerstin B. Pollack Acting Director Manufacturing Studies Board National Academy of Sciences 2101 Constitution Avenue, NW Washington, D.C. 20418	1
Mr. David Poster V.P. Quality & Productibility Bell Helicopter Textron P.O. Box 482 Ft. Worth, TX 76101	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. John R. Potter Executive Vice President, Operations Boeing Military Airplane Company 3801 S. Oliver MS 15-44 Box 7730 Wichita, KS 67277-7730	1
Dr. Thomas H. Probert Encore Computer Corp. 257 Cedar Hill Street Marlboro, MA 01752	1
Mr. Jim Pratt ITT Statistical Programs Group Suite 200 32605 Twelve Mile Road Farmington Hills, MI 48108	1
Mr. Maurice D. Pratt A.T. Kearney, Inc. 1299 Ocean Avenue Suite 333 Santa Monica, CA 90401	1
CDR Tom Pruter NAVAIR Code Air 411B Washington, DC 20361-4110 692-2445	1
Mr. Thomas P. Quinn Assistant Secretary of Defense C3I Room 3E172 The Pentagon Washington, DC 20301	1
Professor Kenneth Ragsdell 1080 Engineering University of Missouri Columbus, MO 65211	1
Mr. Charles Reading Chief Logistics Management Division AMCPM-LHX-L 4300 Goodfellow Blvd. St. Louis, MO 63120-1798	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Bob Reber Process Management Institute 7801 East Bush Lake Road Bloomington, MI 55435-3830	1
Dr. Joseph Reed ITT-DTC 1600 M Street N.W. Washington, D.C. 20036	1
Mr. Manfred J. Reinhard OSD (P&L) Room 2A330 The Pentagon Washington, DC 20301	1
Prof. Ari Requicha Computer Science Dept. University of Southern California Los Angeles, CA 90089-0782	1
Dr. Richard Reynolds DARPA 1400 Wilson Blvd. Arlington, VA 22209	1
Prof Richard F. Riesenfeld Computer Science Dept. University of Utah 3190 MEB Salt Lake City, UT 84112	1
Prof. James Rinderle Dept. of Mechanical Engineering Carnegie-Mellon University Pittsburgh, PA 15213	1
Mr. Harry V. Roberts 1353 Burr Oak Road Homewood, IL 60430	1
Dr. Robert L. Rosenfeld DARPA-ISTO 1400 Wilson Boulevard Arlington, VA 22209	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Jim Rupp Manager of Technology Systems Integration Division IBM 6600 Rockledge Drive, Room 4326 Bethesda, MD 20817	1
LTG V.M. Russo Director, Defense Logistics Agency Cameron Station Alexandria, Virginia 22314-6401	1
Mr. Mike Ryder VHSIC -Program Management IBM, Federal Systems Division 9500 Godwin Drive Manassas, VA 22110	1
Dr. Ajit Sabnis Aerojet Weapons Systems Bldg. 160, P.O. Box 296 Azusa, CA 91702	1
Dr. Art Sanderson Chairman, ECSE Department RPI Troy, NY 12180	1
Prof. Steven Schach Box 70, Station B Nashville, TN 37235	1
Mr. Tom Schaeffer OASN (RE&S) The Pentagon Room 5E813 Washington, D.C. 20330	1
Mr. Roger T. Schappell Martin Marietta I & CS P.O. Box 1260, MS 4443 Denver, CO 80201-1260	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. Robert Schell Executive Vice President Aerojet Ordnance Co. 2521 Michelle Drive Tustin, CA 92680	1
Mr. Joel Schoen Mail Stop A395 Mitre Corporation Burlington Road Bedford, MA 01730	1
Mr. John Schrader Branch Chief System Engineering and Analysis McDonnell Douglas Astronautics Co. Dept 462, Bldg 101A P.O. Box 516 St. Louis, MO 63166	1
Dr. Jack Schwartz DARPA-ISTO 1400 Wilson Boulevard Arlington, VA 22209-2308	1
Major Richard Schwartzman Production Officer Headquarters Army Material Command AMCPD-PA 5001 Eisenhower Avenue Alexandria, VA 22333	1
Mr. Gene Seefeldt Manager for Manufacturing Engineering John Deere Highway 386 Dubuque, IA 52001	1
Mr. John Sheridan Vice President Ballistic Systems Division Boeing Aerospace P.O. Box 3999 Seattle, WA 98124	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. S. Young Shin DoD Product Engineering Service Office c/o Defense Logistics Agency Alexandria, VA 22304-6183	1
Mr. Seymour Selig Board on Mathematical Sciences National Research Council 2101 Constitution Ave. N.W. Washington, DC 20418	1
Mr. Jerry Shumaker AFWAL/MTC Bldg. 653, Room 203 Wright-Patterson Air Force Base WPAFB, OH 45433-6533	1
Mr. Howard J. Siegel Director Production Engineering and Computer Aided Technology McDonnell Aircraft Company P.O. Box 516 Department 380 Bldg 271 Saint Louis, MO 63166-0516	1
Mr. Stan Siegel Vice President, Operations Aerospace Industries Association 1250 Eye Street, N.W. Washington, D.C. 20005	1
Mr. Ray Siewert DR&E Rm 3D1089 The Pentagon Washington, DC 20301	1
Dr. Kamar J. Singh General Electric Aircraft Engine Group MD A317 8500 Governor's Hill Drive Cincinnati, OH 45215	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. Marko Slusarczuk, CSED 943 South 26th St. Arlington, VA 22202	10
Ms. Elissa I. Sobolewski DARPA-DMO 1400 Wilson Boulevard Arlington, VA 22209-2308	1
Dr. A. Somoroff NAVAIR-51 Naval Air Systems Command Room 862 Jefferson Plaza 2 Washington, DC 20361	1
Mr. Michael C. Smith Science Application International Corp. MS T-7-1 1710 Goodridge Drive McLean, VA 22102	1
MGen. Richard D. Smith HQ AFLC/MM Wright Patterson AFB, OH 45433	1
Mr. Donald Snyder Vice President, Aircraft Engineering McDonnel Aircraft Company Dept. 380, Bldg.33 Level 5, Room 556 St. Louis, MO 63166	1
Dr. James E. Spates 8609 Irvington Avenue Bethesda, MD 20817	1
Mr. Bob Sprague General Electric Company 1 Neumann Way Mail Drop A305 Cincinnati, OH 45215-6301	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Guntis Sraders Land Warfare DUSD Tactical Warfare Programs Room 3E1044 The Pentagon Washington, D.C. 20301	1
Mr. Wm. O. Steinberg Joiner Associates Inc. Madison, WI 53705	1
MG Lynn H. Stevens Commandant, Defense Systems Management College Fort Belvoir, Virginia 22060-5426	1
Mr. Jack Strickland Director Industrial Productivity & Quality OASD (P&L) Room 2A318 The Pentagon Washington, DC 20301	1
Dr. Sarosh Talukdar Electrical & Computer Engineering Dept Carnegie Mellon University Pittsburgh, PA 15213	1
Mr. Bill Tarbell SEA 90 Naval Sea Systems Command 1102 Crystal Park 1 Arlington, VA 22202	1
MG David Teal HQ AFSC/SD Andrews AFB, DC 20334	1
Dr. Jay M. Tenenbaum Schlumberger Fellow Schlumberger Palo Alto Research 3340 Hillview Avenue Palo Alto, CA 94304	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. Myron Tribus 350 Britto Terrace Fremont, CA 94538	1
Mr. David J. Trosky LHX Program Manager's Office 4300 Goodfellow Blvd. St. Louis, MO 63120-1798	1
Mr. Stan Trost Lawrence Livermore National Laboratory P.O. Box 808, L-153 Livermore, CA 94550	1
Mr. Nate Tupper AFWAL/MLT Wright Patterson AFB, OH 45433-6533	1
Dr. Joshua Turner CII 7207 Rensselaer Polytechnic Institute Troy, NY 12180	1
Mr. Richard S. Ullman ITT Defense Technolgy Corporation 1000 Wilson Boulevard Arlington, VA 22209	1
Mr. Tim VanBibber McDonnell Douglas Astronautics Co. St. Louis Division Dept. E501, Bldg. 107 P.O. Box 516 St. Louis, MO 63166	1
Mr. Ron Vasseu Aerospace Corp. Box 92957, MS M6-211 Los Angeles, CA 90099	1
Dr. Richard A. Volz Professor and Head Department of Computer Science Zachry Engineering Center Texas A & M University College Station, TX 77843-3112	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Chuck Wagner AFWAL/MTC Bldg. 653, Room 203 Wright Patterson Air Force Base WPAFB, OH 45433-6533	1
Ms. Adrienne Walls U.S. Army Tank-Automotive Command Ride Center AMSTA-TMM Warren, MI 48397-5000	1
Mr. Michael Watts Northrop Product Definition Development Center Mail Stop -Dept. 3000 One Northrop Avenue Hawthorne, CA 90250	1
Mr. Gerald Webster Bldg. 543/D214 McDonnell Douglas Helicopter Co. 5000 E. McDowell Road Mesa, AZ 85205	1
Ms. Mitzi M. Wertheim IBM-SID 6600 Rockledge Drive Room 3316 Dept 60Y Bethesda MD 20817	1
Mr. Jim White John Deere, Dubuque P.O. Box 538 Dubuque, IA 52004-0538	1
Dr. Daniel E. Whitney C.S. Draper Laboratory 555 Technology Square, MS1E Cambridge, MA 02139	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Leigh Whitney Senior Vice President for Government Operations Philip Crosby Associates, Inc. 807 W. Morse Blvd. P.O. Box 2369 Winter Park, FL 32790-2369	1
Dr. Peter Will Hewlett Packard Labs 1501 Page Mill Road Palo Alto, CA 94304	1
Commander, U.S. Army Missle Command Attn. AMCPM-FM (Mr. George Williams) Bldg. 5400 Redstone Arsenal, AL 35898-5793	1
Prof. John Williams AESL Room 1-272 Civil Engineering Dept. MIT 77 Massachusetts Avenue Cambridge, MA 02139	1
Col. Richard Williams DUSD (S&TNF) The Pentagon Washington, D.C. 20301	1
Mr. Walter Winanas Integraph Corporation 2051 Mercator Drive Reston, VA 22091	1
Dr. Michael Wiskerchen Star Lab/Sera Stanford University Stanford, CA 94305	1
Dr. Stanley Wolfe Department of Energy ECUT-CE12 Washington, D.C. 20585	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Yuin Wo American Supplier Institute Six Parklane Blvd. Suite 411 Dearborne, MI 48126	1
Dr. Tony Woo National Science Foundation Room 1108 1800 G Street, NW Washington, DC 20550	1
Dr. Lang W. Woodruff Deputy Under Secretary S&TNF Rm 3E130 The Pentagon Washington, DC 20301	1
Mr. Jonathan Wood 3301 Applegrove Court Herndon, VA 22071	1
Dr. Ralph Woods General Electric Company River Road KWC 291 Schnectady, NY 12301	1
Dr. Michael Wozny Rensselaer Polytechnic Institute 110 Eight Street Troy, NY 12180-3590	1
Mr. Mike Zsak HQ AFSC/PLE Andrews AFB, MD 20334-5000	1
CSED Review Panel	
Dr. Dan Alpert, Director Program in Science, Technology & Society University of Illinois Room 201 912-1/2 West Illinois Street Urbana, Illinois 61801	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. Barry W. Boehm TRW Defense Systems Group MS R2-1094 One Space Park Redondo Beach, CA 90278	1
Dr. Ruth Davis The Pymatuning Group, Inc. 2000 N. 15th Street, Suite 707 Arlington, VA 22201	1
Dr. C.E. Hutchinson, Dean Thayer School of Engineering Dartmouth College Hanover, NH 03755	1
Mr. A.J. Jordano Manager, Systems & Software Engineering Headquarters Federal Systems Division 6600 Rockledge Dr. Bethesda, MD 20817	1
Mr. Robert K. Lehto Mainstay 302 Mill St. Occoquan, VA 22125	1
Dr. John M. Palms, President Georgia State University University Plaza Atlanta, GA 30303	1
Mr. Oliver Selfridge 45 Percy Road Lexington, MA 02173	1
Mr. Keith Uncapher University of Southern California Olin Hall 330A University Park Los Angeles, CA 90089-1454	1
IDA	
General W.Y. Smith, HQ	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. Philip Major, HQ	1
Dr. Robert E. Roberts, HQ	1
Dr. Gary C. Comfort, OED	1
Mr. Harold E. Bertrand, STD	1
Mr. William E. Cralley, SF&RD	1
Dr. Edwin Townsley, STD	1
Dr. John F. Kramer, CSED	1
Dr. Richard Wexelblat, CSED	1
Ms. Anne Douville, CSED	1
Mr. Terry Mayfield, CSED	1
Dr. Dennis W. Fife, CSED	1
Dr. James P. Pennell, CSED	10
Ms. Katydean Price, CSED	2
Dr. Robert I. Winner, CSED	25
IDA Control & Distribution Vault	3